

# **Solutions for Beam Stripping at RIA**

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## Beam stripping at RIA

4 beam stripping positions

- Driver at 10.5 MeV/u (liquid Lithium, Carbon foil wheel)
- Driver at  $\sim 80$  MeV/u (liquid Lithium, Carbon foil wheel)
- Post accelerator at 10-30 keV/u (extended, windowless gas cell)
- Post accelerator at  $\sim 600$  keV/u (Carbon foil)

Benchmark currents:

- Driver  $^{238}\text{U}$ , 400 MeV/u,  $5\text{p}\mu\text{A}$
- Post accelerator, heavy ions,  $10^9$ - $10^{12}$  1/s



# Gas Stripper in Post Acceleration

Increase charge states at low energies to avoid broad distribution over many charge states

Concept proven: P. Decrock et al., Rev. Sci. Instrum. 68 (1997) 2322

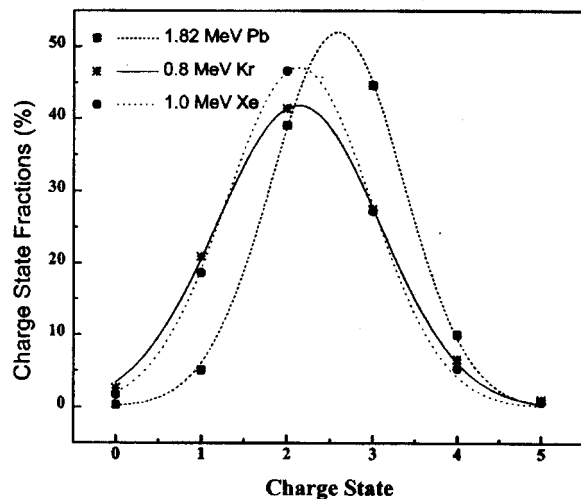
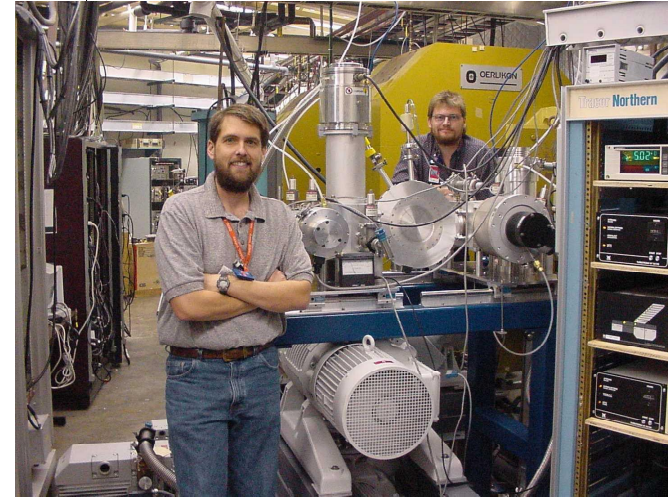
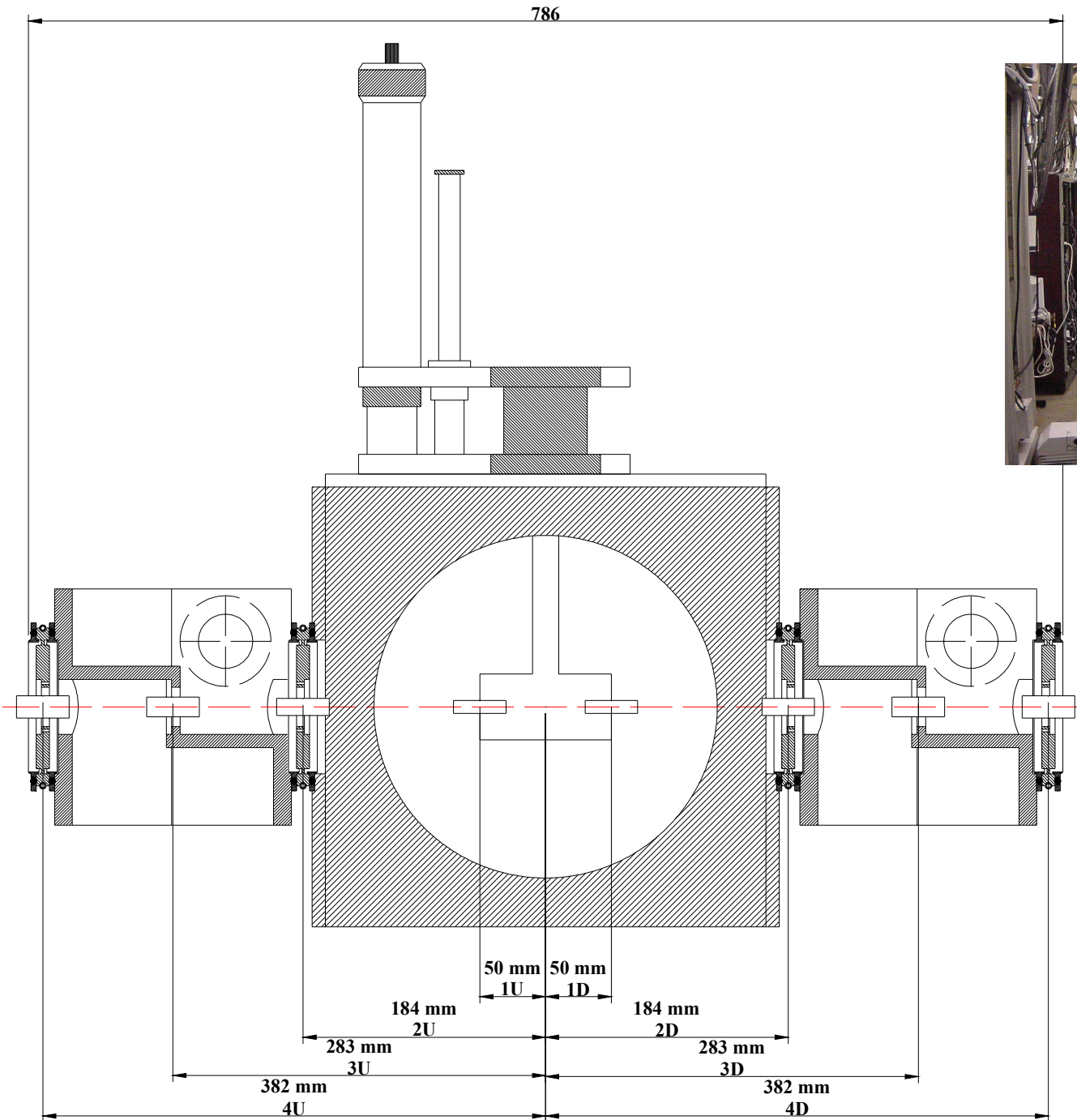


FIG. 6. Measured equilibrium charge state fractions for Pb (1.82 MeV), Kr (0.8 MeV), and Xe (1.0 MeV). The fitted curves shown represent Gaussian distributions.

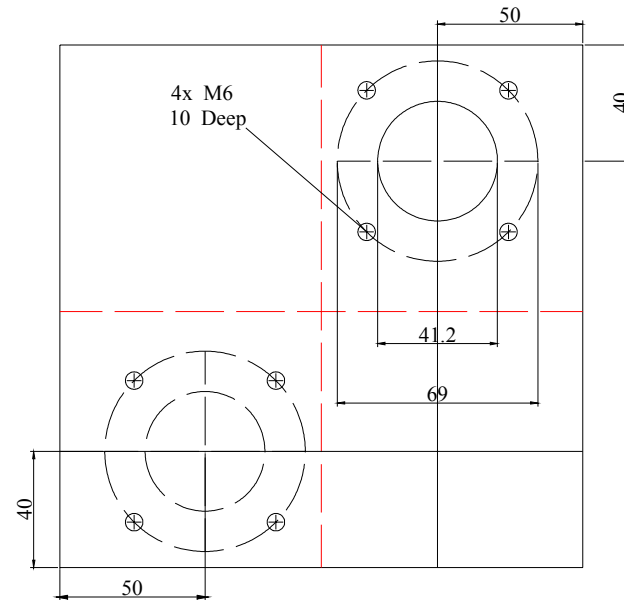
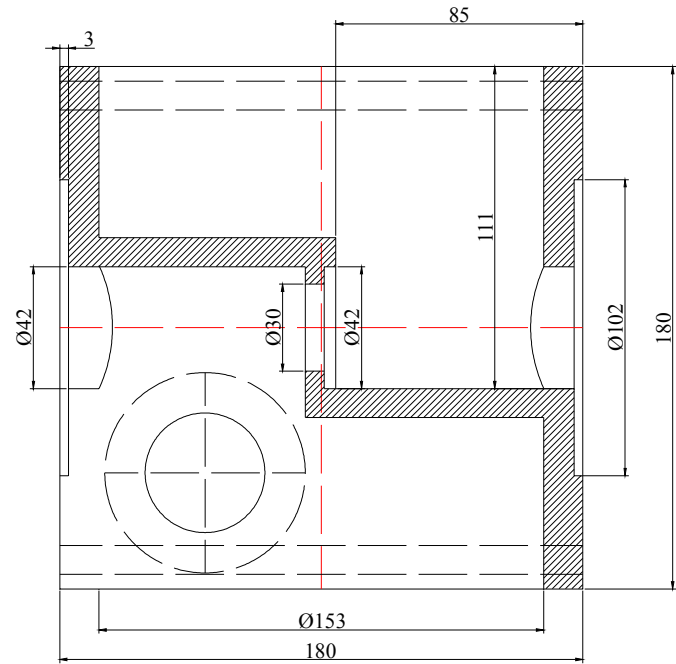
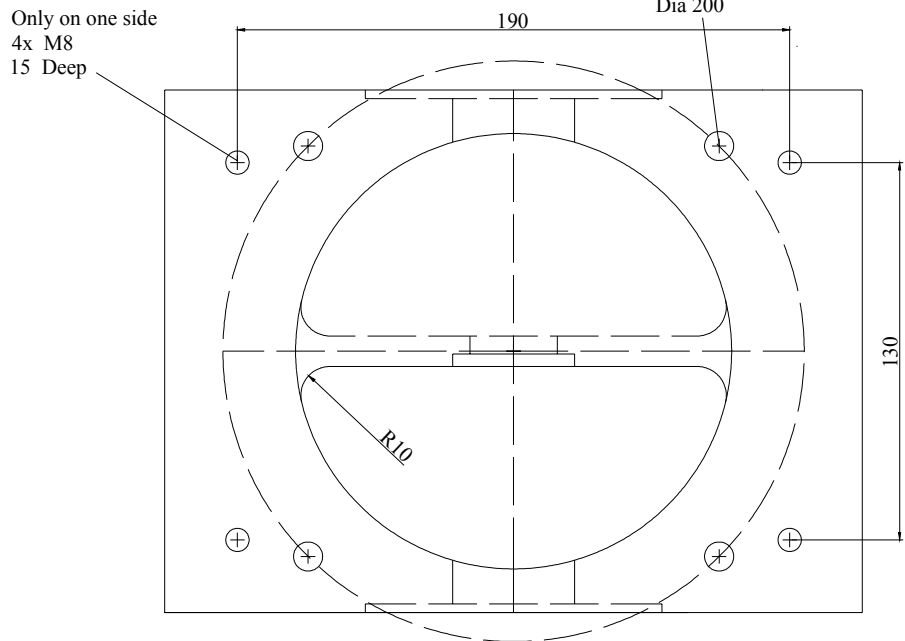
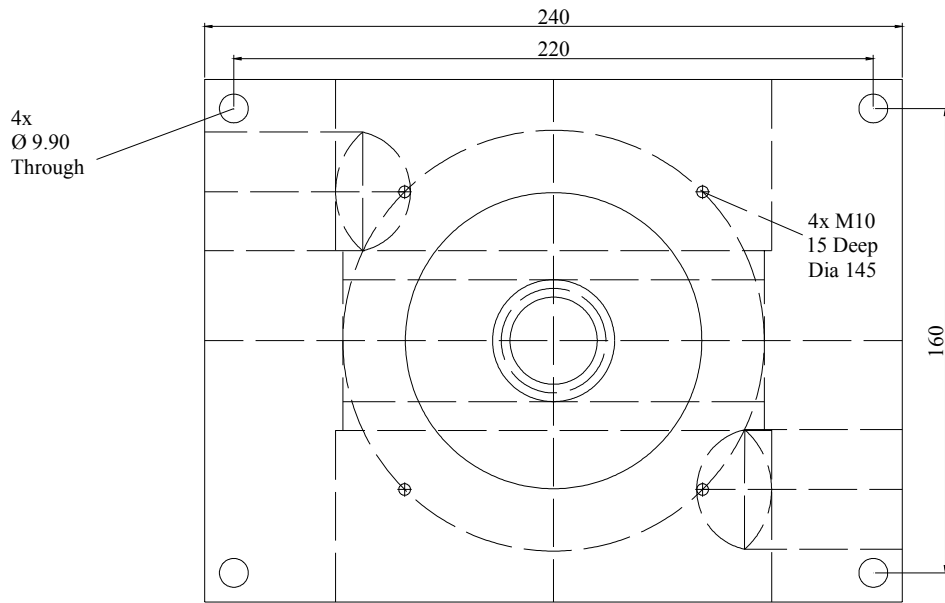
Needs:

- Design with large apertures to fit to beam optics
- Exploration of parameter space to find optimum operating conditions (including beam energy and gas type)



at ORNL





# Gas Flow Calculations

Gas Type	
He	
P <sub>o</sub> [mbar]	0.667
s <sub>1</sub> [l/s]	4000

1	d <sub>01U</sub> [cm]		d <sub>01D</sub> [cm]	1.0
4	l <sub>01U</sub> [cm]	Laminar Flow	l <sub>01D</sub> [cm]	4
0.002	P <sub>1</sub> [mbar]		P <sub>1</sub> [mbar]	0.002
6.899	q <sub>01U</sub> [mbar*l / s]		q <sub>01D</sub> [mbar*l / s]	6.899

1000	s <sub>2U</sub> [l / s]		s <sub>2D</sub> [l / s]	1000
1.3	d <sub>12U</sub> [cm]		d <sub>12D</sub> [cm]	1.3
4.0	l <sub>12U</sub> [cm]	Knudsen Flow	l <sub>12D</sub> [cm]	4.0
0.0001	P <sub>2U</sub> [mbar]		P <sub>2D</sub> [mbar]	0.0001
0.0982	q <sub>12U</sub> [mbar*l / s]		q <sub>12D</sub> [mbar*l / s]	0.0982

1000	s <sub>3U</sub> [l/s]		s <sub>3D</sub> [l / s]	1000
1.5	d <sub>23U</sub> [cm]		d <sub>23D</sub> [cm]	1.5
4.0	l <sub>23U</sub> [cm]	Molecular Flow (d<l)	l <sub>23D</sub> [cm]	4.0
1.881E-06	P <sub>3U</sub> [mbar]		P <sub>3D</sub> [mbar]	1.881E-06
0.0018	q <sub>23U</sub> [mbar*l / s]		q <sub>23D</sub> [mbar*l / s]	0.0018

1.7	d <sub>34U</sub> [cm]		d <sub>34D</sub> [cm]	1.7
4	l <sub>34U</sub> [cm]	Molecular Flow (d<l)	l <sub>34D</sub> [cm]	4.0
725E-05	q <sub>34U</sub> [mbar*l / s]		q <sub>34D</sub> [mbar*l / s]	4.725E-05



## Gas cooled stripper wheel

10.5 MeV/u  $^{238}\text{U}$ : energy loss = 125 MeV/mg/cm<sup>2</sup> in Carbon

power deposition for 5 pμA ion beam in 0.5 mg/cm<sup>2</sup> foil:

312.5 Watt

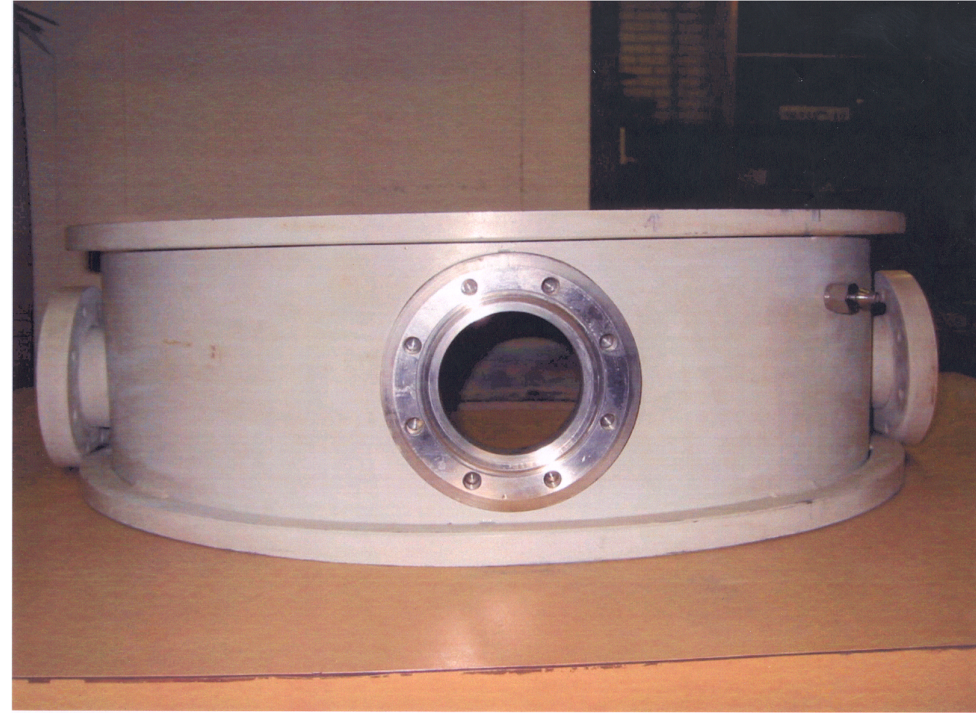
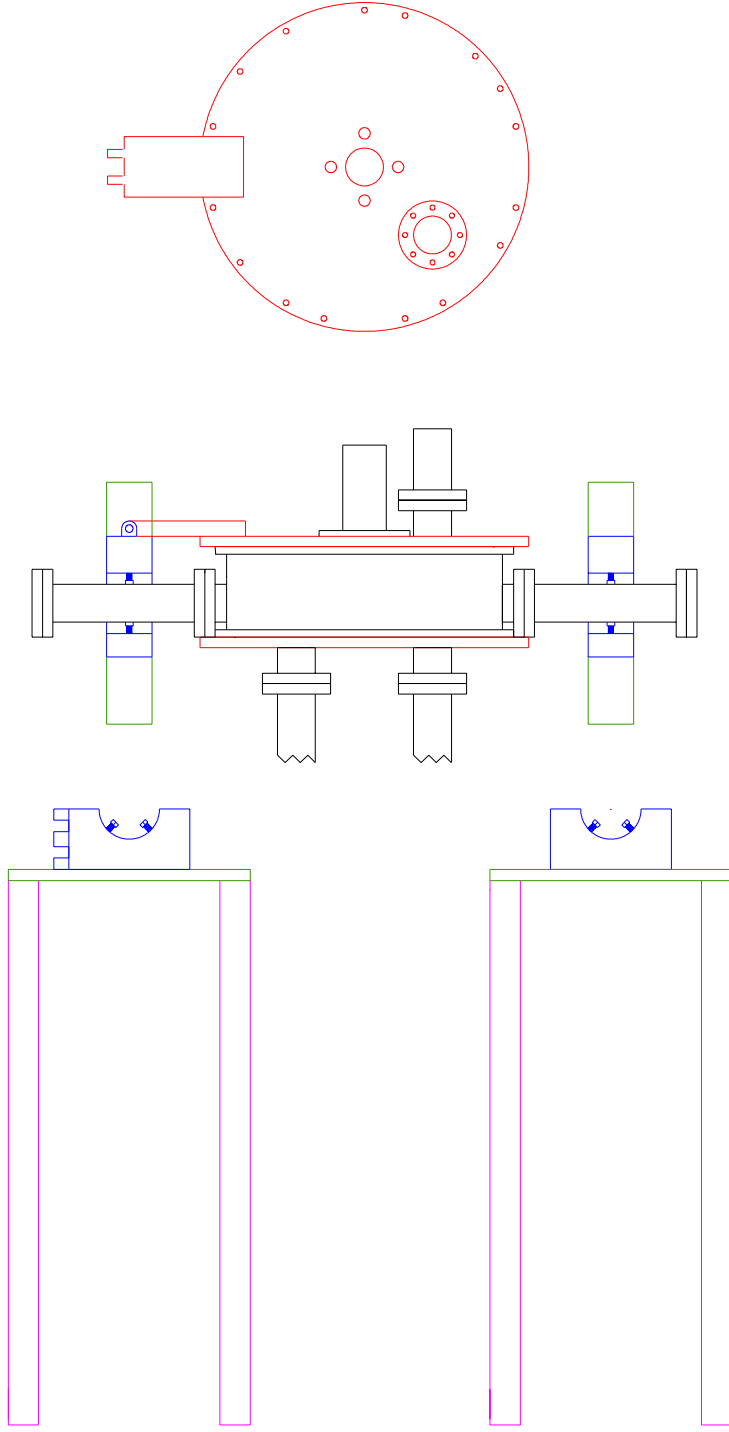
In order to keep the temperature on the beam spot low enough, we will have to keep the wheel and the foil mounts at or below room temperature. Assuming a surface area of the wheel of 1 m<sup>2</sup>, a temperature difference of 200 K to the cooled shields and ideal heat emission, we can only radiate away 90 Watt.

Gas cooling should be checked out





## Stripper wheel test setup





# What can we expect from foil stripping

GSI

## Texas A&M Measurements

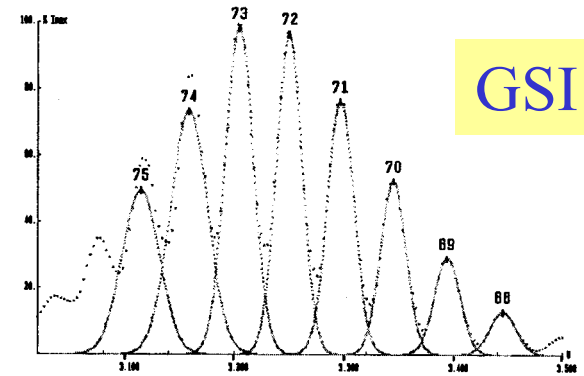
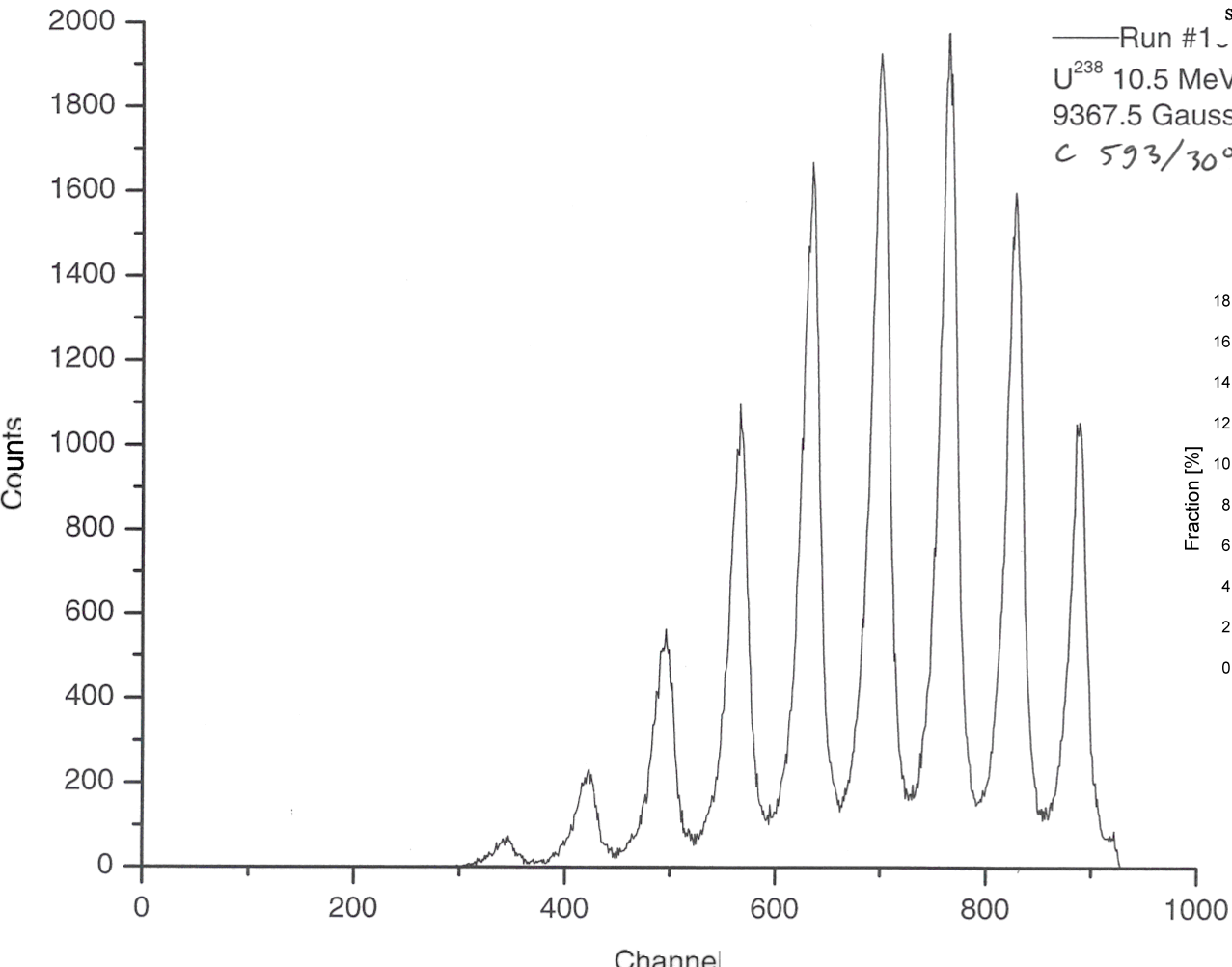
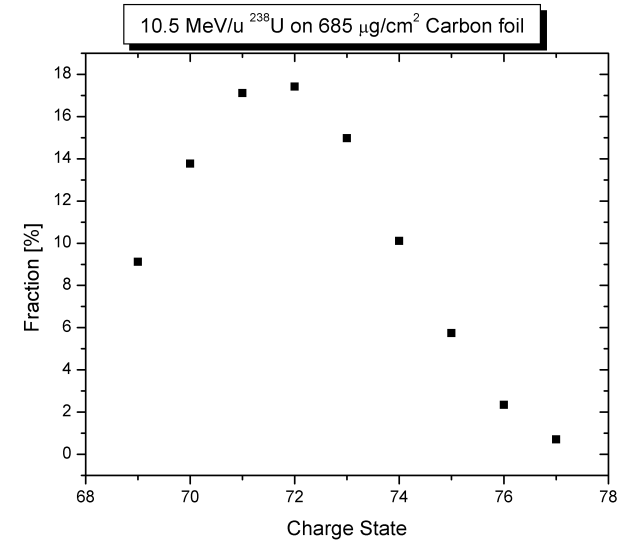
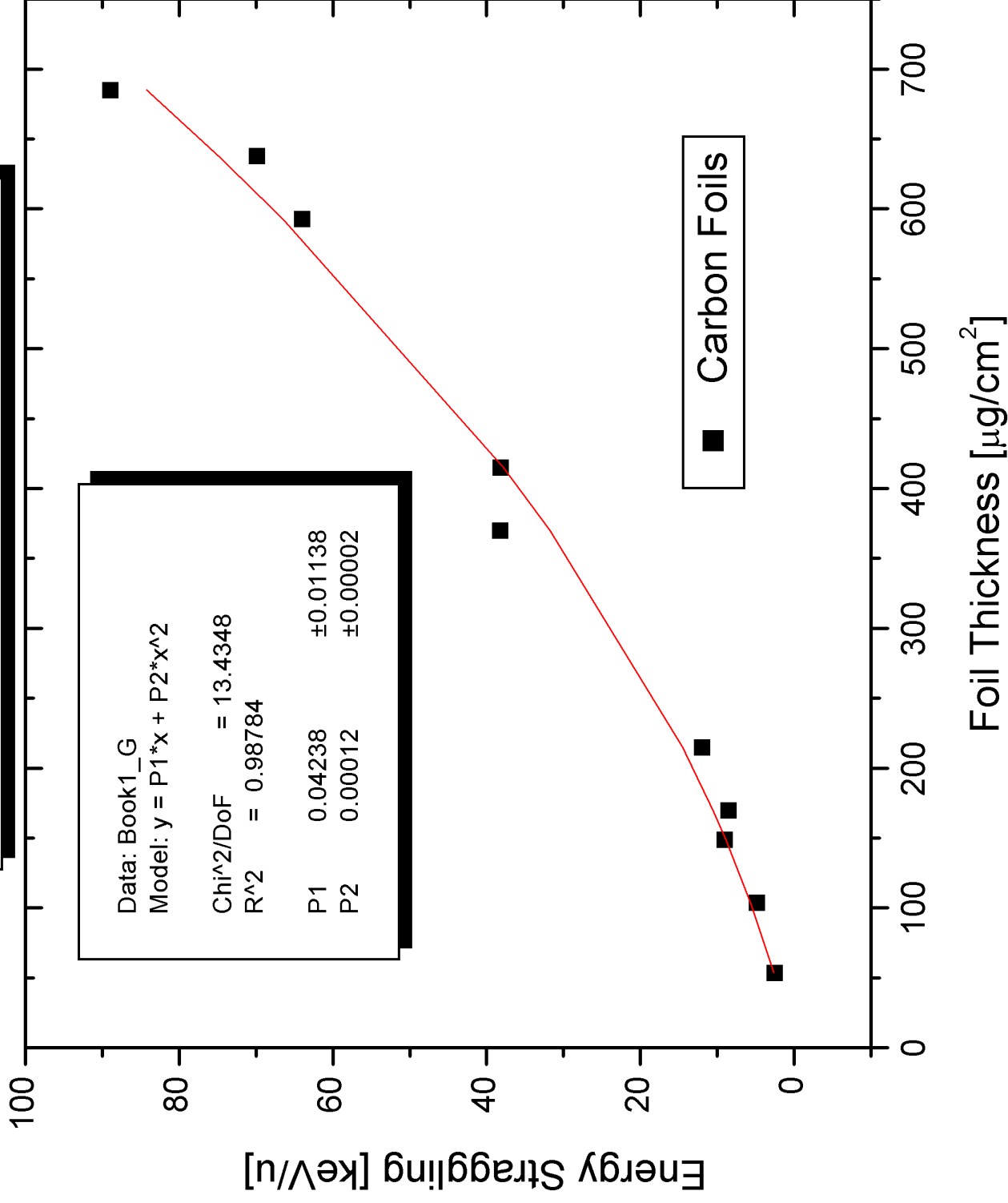


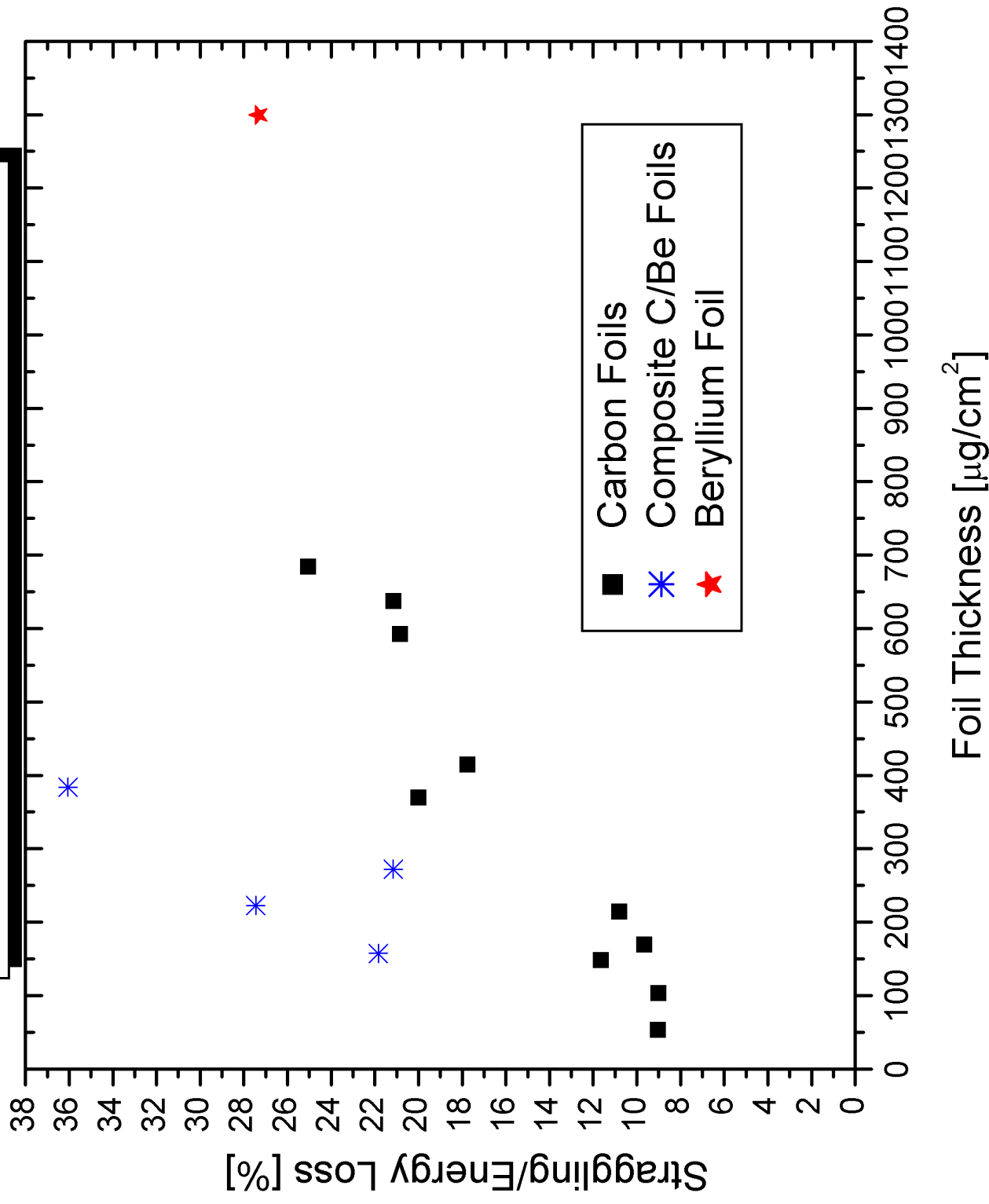
Figure 1: Charge state distribution of uranium beam stripped in a 0.5mg/cm<sup>2</sup> carbon foil at 11.4MeV/u



# Energy Straggling of 10.5 MeV/u <sup>238</sup>U in Carbon Foils



Ratio Energy Straggling to Energy Loss [%]



Foil Thickness [ $\mu\text{g}/\text{cm}^2$ ]



## Possible Timeline

### First project year:

Design of short Helium gas stripper.

Design of gas cooled rotating wheel test setup.

Analysis of first measurements of stripping parameters at 10.5 MeV/u with standard foils.

### Second project year:

Construction and off-line tests of gas cooled rotating wheel setup.

If additional funds become available, construction of short helium gas stripper.

Further measurement and analysis of stripping parameters with different targets at relevant energies.

### Third project year:

High power tests with gas cooled rotating Carbon foil wheel at Argonne's Dynamitron.

Measurement of stripping parameters with short Helium gas stripper at Argonne's Dynamitron.

